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MODIFIED SCOTT MODEL 8300 'HYDRO-PAK'

C. T. Kincaid, et al

Navy Experimental Diving Unit
Washington, D. C.

7 January 1953

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REPORT NO. 9-52

NAVY EXPERIMENTAL DIVING UNIT

37

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Ia

NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

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MODIFIED SCOTT MODEL 8300 "HYDRO-PAK"

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13. ABSTRACT

The Scott Model 8300 air-demand self-caontained underwater breathing apparatus has been tested by a series of swimming, diving, and depth breathing resistance runs. It does not meet all of the specifications outlined by the Chief of Naval Operations for an apparatus of its type, mainly because it lacks an interchangeable mouthpiece and facemask arrangement. However, it is sound in principle, excellent in construction, and satisfactory for many shallow water diving operations.

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FOREWORD

Report 9-51, submitted to the Bureau of Ships on 22 June 1951, covered the test of the original Scott Model 8300 air demand self-contained underwater breathing apparatus for use in the naval service to depths of 150 feet. The report concluded that the equipment was sound in principle and that it could be used to depths of 150 feet if the deficiencies noted were remedied; it specified the following changes as being necessary:

1. The air capacity of the unit should be approximately doubled.
2. The bottles should be so designed that the swimmer will barely float when the bottles are fully charged.
3. The shoulder straps should be redesigned or padded so that chafing is eliminated.
4. The hose leading from the regulator to the demand valve should have fittings that are readily disconnected.
5. The mask or the face glass should be changed so that there is more nose clearance.

The report recommended that, if sufficient need for this specific equipment existed, the foregoing changes be made and that the unit be given comprehensive field tests.

This report covers the evaluation of the unit as modified to conform to the outlined changes. Pertinent parts of the first report are incorporated into this report where ever it is desirable, to minimize cross-reference.

CONTENTS

I. OBJECT

This evaluation was made to determine the suitability of the Scott Model 8300 air demand self-contained underwater breathing apparatus for use as a shallow water swimming and diving unit.

II. DESCRIPTION

The overall appearance of the modified diving unit is essentially unchanged from that of the original. It consists of a back pack and a mask assembly. The back pack comprises the back plate, the harness, the two air flasks, a manifold, a reducer regulator, and the air supply tube; provision is made on the manifold for charging the bottles and for checking the bottle pressure with a gage. The mask assembly comprises the face piece, the demand valve, and the exhaust valve. Each of the air cylinders contains 53.5 cubic feet or free air when charged to 2000 psig, making available 107 cubic feet of free air. Each cylinder is equipped with an individual shut-off valve and with an I.C.C. safety device. Individual cylinder clamps and fittings provide for removing either cylinder independently, so that spare cylinders can be carried and used as required.

The reducer regulator can be set to deliver a pressure from 55 psi to 90 psi over bottom pressure. The regulator is equipped with an over pressure relief valve to guard against excess pressure to the demand valve. The air supply tube leads upward between the two cylinders, over the right shoulder, and to the demand valve.

The molded rubber face piece contains a large shatterproof circular window giving a wide field of vision. The demand valve is attached to the right side. The exhaust valve is attached to the left side. A balance tube between the exhaust valve and the demand valve provides for their operation at the same hydrostatic pressure. Incorporated into the demand valve is a demand valve bypass, operated by a large button, which can be depressed to give a continuous flow through the mask; this bypass can be used to clear the mask completely of water when it has been partially or fully flooded. An "air economizer" built on to the demand valve provides a surface breather which is readily adaptable to a snorkel attachment.

An air reserve valve incorporated into the regulator permits free flow of high pressure air from the cylinder to the regulator until the cylinder pressure decreases to a critical point. At surface conditions this critical point is around 400 psig. At the critical point the valve so restricts flow that a noticeable breathing resistance builds up, warning the diver that his air supply is low. Turning the reserve air supply knob clockwise reduces breathing resistance to its original level, until the reserve air is consumed.

A balsa float is provided with the back pack to overcome the initial negative buoyancy of the fully charged apparatus. The unit is balanced in the water, with the back plate harnessed at the waist and shoulders. There is no chest harness; two shoulder straps and a waist belt with a quick release buckle provide easy donning and doffing. The entire harness is adjustable for various builds.

Except for the bottles, the entire unit is built of non-magnetic, corrosion resistant materials.

III. PROCEDURE

The unit was evaluated by a series of twelve swimming runs, and of seventeen diving runs under various conditions of work and pressure. All swimming and diving runs were made to determine endurance of the apparatus under those conditions. Comfort, fit, and subjective surface breathing resistance were determined during these runs. Operation of the demand valve bypass to clear water from the mask was also evaluated.

Subsequent to the personnel runs, two breathing resistance runs were made in the recompression chamber at various increments of depth down to 130 feet. These runs objectively confirmed the subjective complaints of excessive breathing resistance at the greater depths, which had been noted during the tank depth dives. The entire unit was delivered to the manufacturer for correction of the high breathing resistance at depth. It was returned for evaluation after modification of the reducer regulator. A second set of breathing resistance runs showed a satisfactory breathing resistance curve for the unit, in both inspiratory and expiratory pressures.

Because of the favorable carbon dioxide percentages reported in the first evaluation, and because of the difficulty of obtaining representative carbon dioxide samples, no carbon dioxide analyses were made on the modified unit.

A. Swimming runs

The swimming runs were made in the swimming pool at a rate of 1 knot for the duration of the bottle pressure. All swimmers were instructed to use the demand valve bypass as little as possible, to conserve the air supply.

B. Diving runs

The diving runs were made in the pressure tank at depths of 33, 66, 99, and 130 feet, using controlled conditions of work by lifting weights and by cycling.

1. Weight lifting runs were accomplished by having the subjects lift a 67.5-pound weight through 27 inches five, seven, or ten times a minute for a period of 10 minutes, followed by a rest period of 5 minutes.
2. Cycling runs were accomplished by having the subjects cycle at a rate of 20 miles per hour on the cycle speedometer. One run was made cycling 10 minutes and resting 5 minutes. All other runs were made cycling continuously.

C. Breathing resistance

The laboratory breathing resistance machine was set up in the recompression chamber. The machine was set to breathe two liters per stroke, twenty strokes per minute; this rate was accurately maintained for all runs. The machine was left running through-out the run, and cycling was effected by opening and closing an opening in the machine outlet.

The facemask of the unit was placed over a dummy head which was connected to the outlet of the breathing machine. A water manometer connected to the copper pipe which served as a throat for the dummy gave the inspiratory and expiratory pressures developed at that point during operation of the apparatus. Surface measurement of the throat resistance at that point (measured with the mask off) gave a maximum deflection of only 0.4 centimeters of water.

The bottles were charged to 2000 psig or better before each run. Final bottle pressures ranged from 1600 psig to 1100 psig. Regulator pressure was set before the run and checked afterwards.

Resistance was measured once on the surface at the beginning of the run. The apparatus was then taken directly to 130 feet and the resistance was measured at 10 foot stages to 100 feet and at 5 foot stages to 10 feet. A final measurement was made on the surface.

Because of the marked effect of bottle pressure drop upon breathing resistance at depth, the bottle pressure was observed after each reading. An attempt was made in each run to cycle the breathing machine as few times as possible, in order to avoid excessive bottle pressure drop.

Some runs were made to determine the effect of bottle pressure drop at various depths. For various regulator settings a criterion of 20 centimeters inspiratory pressure was taken as being representative of the point at which a man would turn the air reserve supply valve knob. When this criterion was reached, the corresponding bottle pressure was noted; the subsequent decreased inspiratory pressure was also noted.

As a result of the very high depth breathing resistance recorded in run 1-01 of 1 and 2 July (data sheet 3), an attempt was made at surface conditions to duplicate the curve of inspiratory pressure by varying the stroke volume and changing the stroke rate. The data from this run 1-02 are given in data sheet 4.

IV. RESULTS

A. Swimming runs

The results of the twelve swimming runs are tabulated in data sheet 1. Initial bottle pressures ranged from 2000 psig to 2100 psig. Final bottle pressures ranged from 625 psig to 50 psig, the majority being under 200 psig. Total time averaged 71 minutes. The time at which the air reserve valve was turned was not noted for four of the runs; for the other eight runs that time was an average of 54 minutes. Average time on reserve air supply was 17 minutes.

The endurance of the equipment was markedly affected by use of the demand valve bypass button to dump water from the mask.

B. Diving runs

The results of the seventeen diving runs are tabulated in data sheet 2. Initial bottle pressure was 2000 psig. Final bottle pressure ranged from 500 psig to 0 psig.

1. Weight lifting

The average total time at 33 feet was 66 minutes; at 66 feet, 50 minutes; at 99 feet, 23 minutes; and at 130 feet, 25 minutes.

2. Cycling

The average total time at 33 feet was 62 minutes; at 66 feet, 50 minutes; at 99 feet, 30 minutes; and 130 feet, 28 minutes.

C. Breathing resistance

Results of the breathing resistance runs are given in data sheets 3 through 7.

Data sheet 3 is laid out in the form which was used for all depth breathing resistance runs; data sheets 5 and 6 have been abstracted from those particular runs which gave complete curves for inspiratory pressure and for expiratory pressure respectively.

Data sheet 4 shows the result of varying the minute volume of respiration by changing the stroke rate at different stroke volume settings. The flow in liters per minute has been calculated from the product of stroke volume and stroke rate.

Data sheet 7 shows the tabulation, for various regulator settings and for different depths, the bottle pressure at the time the inspiratory pressure had increased to 20 centimeters for a given depth; it also shows the tabulation of the corresponding inspiratory pressure at that time when the bypass has been opened.

V. DISCUSSION

A. General

Comfort and fit of the entire apparatus is good. The face piece leaked somewhat on certain individuals, but such leakage can be eliminated by incorporation of a lip on the mask. The straps secure the equipment to the subject tightly but comfortably. Buoyancy characteristics of the fully charged apparatus with the balsa float are satisfactory.

The demand exhalation balance mechanism performs its function of subjecting both valves to the same hydrostatic pressure. No noticeable breathing resistance change is caused by great variations in the position of the equipment. Even underwater acrobatics failed to cause any apparent change in the breathing resistance.

Design detail and workmanship are excellent. No trouble whatsoever occurred as a result of faulty workmanship. Deleterious effect of long submersion and constant use were not apparent. Operation of all components was satisfactory throughout the evaluation.

B. Modifications

With the exception of item 4, all the recommended changes in report 9-51 (as listed in the foreword to this report) were incorporated into the modified unit. Item 4, which recommended that the air supply hose have fittings which can be readily disconnected, should be accomplished in any production model. The lack of easily disconnected fittings proved a nuisance in maintenance and stowage of the equipment.

Item 1, concerning the air capacity, was more than satisfied by the increase from 34.4 to 107.0 cubic feet of free air.

Item 2, concerning the buoyancy, was satisfied by the addition of the balsa float to the back pack. This particular item would have to be the subject of an individual design study for any particular set of bottles.

Item 3, concerning the shoulder straps, was satisfied by redesign of the harness and by changing the material to nylon webbing.

Item 5, concerning nose clearance, was satisfied by having the circular window on the mask moved farther from the face.

The demand valve bypass (apparently not incorporated into the original unit) provides a very satisfactory method of clearing all water from the facepiece. The entire mask can be removed and replaced underwater, and cleared subsequently with a minimum or difficulty.

The modified reducer regulator now provides satisfactory control of the demand valve pressure so that the depth breathing resistance curve approximates a straight line at proper regulator settings.

C. Swimming runs

As might be expected from a more than threefold increase in bottle capacity, the modified apparatus lasted an average of more than three times that of the original. Since there was a wide variation in physical characteristics among the swimmers, a comparison of averages is not too meaningful; however, the general average of 71 minutes total time is reasonably representative of what should be expected in duration.

Other characteristics as previously discussed were noted during the swimming runs.

D. Diving runs

Except for the 33-foot runs, the work rate used for half the runs were identical to that used in the previous evaluation. As might be expected again, the average time is around three times that of the previous report.

The cycling runs, which were intended to duplicate swimming respiration rates, apparently gave a respiration rate very close to that of weight lifting.

The apparatus was worn to the bottom until the subject felt he could no longer draw a breath. No allowance was made for return to surface conditions. Except for three cases (which may have lost pressure from leakage), a considerable pressure remained in the bottles at the termination of the run. The subsequent depth breathing resistance runs show that a decrease in depth will enable a subject to breathe more easily for any given bottle pressure.

Hence (although this was not actually tried subjectively), presumably a man could breathe freely during a constant return to the surface once breathing resistance became intolerable at any depth.

E. Breathing resistance

Figure 1 shows graphically the breathing resistance of the modified unit at a 70-psi regulator setting, as delivered. Figure 2 shows the surface characteristics at that time for various minute volumes.

Figure 3 shows the comparative curves of breathing resistance at various settings of the modified regulator. It is noticeable from these curves and from a study of data sheet 5 that increasing the regulator setting beyond 75 psi has little effect on the inspiratory pressure. An unrecorded run at higher regulator setting that 85 psi showed this to be the case.

Figure 3 showing the depth inspiratory pressure curves for various regulator settings, graphically illustrates the large effect of lower regulator pressures in increased inspiratory pressure. Comparison of this curve with figure 1 shows the decreased depth inspiratory pressure brought about by the modification of the reducer regulator. The curve for the unmodified reducer regulator at 70 psi closely approximates the curve for the modified reducer regulator for 55 psi in characteristic shape, but is even higher, and has a more steeply rising slope after the break near the 50-foot depth.

In the modified reducer regulator, the 55 psi curve is the most irregular, with the highest resistance at the greater depths. The 65-psi curve is somewhat more smooth, with less resistance at the greater depths. The 75-psi and 85-psi curves are the most nearly straight line, with the least resistance of all the curves at the greater depths. As figure 4 shows, they have a slope very nearly that of their corresponding expiratory pressure curves. The similiarity of slope, in conjunction with the straight line approximation, indicates that the major variable effect in the inspiratory pressure is that of the increased air density.

Data sheet 7 showing the points at which inspiratory pressure reaches 20 centimeters, is graphically illustrated in figure 5 and figure 6. Figure 5 shows the decreased bottle pressure for which inspiratory pressure reaches 20 centimeters at various depths for the 85-psi regulator setting. Figure 6 shows the inspiratory pressure at various depths for the 85-psi regulator setting after the reserve air supply knob has been turned. These curves give some indication of how long the equipment can be expected to last at various depths for a given initial bottle pressure and for a constant respiration rate.

Because the increase in inspiratory pressure with fall of bottle pressures will force the user to shallower depth, depth time specifications do not have to include allowance for attaining zero bottle pressure. However, to forestall any possibility of bends while using the apparatus, the non-decompression curve from the standard decompression tables should be observed rigidly as a maximum time limitation for the equipment at any given depth.

At shallower depths, the maximum non-decompression diving time is far beyond the bottle capacity, but at 50 feet and deeper it is possible for the bottle capacity to extend beyond the maximum non-decompression time. The following table should be applied:

DEPTH feet	TIME minutes
40	120
50	78
60	55
70	43
80	35
90	30
100	25
110	20
120	18
130	15

To provide an extra safety factor, this table should be applied to the total time of dive, including the time of descent and of ascent.

VI. CONCLUSIONS

The Scott Model 8300 modified air demand self-contained underwater breathing apparatus can be used for shallow water swimming and diving to depths of 130 feet. It is generally trouble-free, and is safe when used with all due regard to the precautions which must be observed in any diving apparatus.

As presently constituted, the equipment does not meet the Chief of Naval Operations specifications for air self-contained underwater breathing apparatus for use by Underwater Demolition Units, principally in that it does not have an interchangeable mouthpiece-facemask arrangement. However, if the model were put into production so that equipment and spare parts were readily available, it would provide satisfactory breathing equipment for a large number of shallow water diving tasks.

VIII. DATA SHEET INDEX

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SWIMMING RUNS
in swimming pool
at 3-foot depth
with 1-knot rate

RUN	PRESSURES (psig) initial	PRESSURES (psig) final	TIME (minutes) normal	TIME (minutes) reserve	TIME (minutes) total
S-1	2000	625	43	05	48
S-2	2050	200	-	-	60
S-3	2000	130	45	19	64
S-4	2100	50	60	22	82
S-5	2000	50	43	12	55
S-6	2100	50	57	15	72
S-7	2100	50	72	17	89
S-8	2100	350	52	13	65
S-9	2100	150	58	35	93
S-10	2100	225	-	-	70
S-11	2075	50	-	-	69
S-12	2100	80	-	-	79
Average			54	17	71

DATA SHEET 1

DIVING RUNS
in pressure tank
at various depths

WEIGHT LIFTING RUN	DEPTH (feet)	PRESSURES (psig) initial	final	WORK RATE	TIME (minutes) normal	reserve	total
T-2	33	2000	100	7W10R5	46	29	75
3T-4	33	2000	200	5W10R5	30	10	40
T-5	33	2000	0	7W10R5	65	19	84
T-6	66	2000	240	10W10R5	30	12	42
T-7	66	2000	100	10W10R5	45	13	58
T-12	99	2000	450	10W10R5	21	7	28
T-14	130	2000	300	10W10R5	20	6	26
T-16	130	2000	375	10W10R5	18	6	24
CYCLING RUN							
T-1	33	2000	0	20C10R5	--	--	63
T-3	33	2000	200	20C60R0	45	15	60
T-8	66	2000	175	20C60R0	51	9	60
T-9	66	2000	0	20C38R0	30	8	38
T-10	99	2000	350	20C26R0	19	7	26
T-11	99	2000	500	20C24R0	20	4	24
T-13	99	2000	250	20C38R0	30	8	38
T-15	130	2000	325	20C27R0	19	8	27
T-17	130	2000	350	20C29R0	23	6	29

Seven lifts per minute for 10 minutes, resting 5 minutes

Twenty mph cycling for 10 minutes, resting 5 minutes

DATA SHEET 2

SCOTT AIRPAK
breathing resistance at various depths
with 2000 psig bottle pressure
and with demand valve set 70 psi over bottom.

Measurements taken in air in compression chamber,
with breathing machine set at 2 liters per stroke,
and 20 strokes per minute.

Manometer high arm and low arm readings
obtained in centimeters of water.

	INSPIRATION				EXPIRATION			
DEPTH feet	High cm.H20	Low cm.H20	Total cm.H20	Total in.H20	High cm.H20	Low cm.H20	Total cm.H20	Total in.H20
0	3.5	3.0	6.5	2.56	3.2	3.4	6.6	2.70
11	4.2	3.7	7.9	3.11	4.2	4.3	8.5	3.34
22	4.4	4.1	8.5	3.34	5.2	5.5	10.7	4.12
33	4.8	4.4	9.2	3.52	6.2	6.9	13.1	5.16
40	5.4	4.9	10.3	4.06	6.5	6.9	13.4	5.27
45	5.7	5.4	11.1	4.37	6.8	7.2	14.0	5.51
50	6.8	6.2	13.0	5.12	6.9	7.2	14.1	5.55
55	7.7	7.3	15.0	5.91	6.9	7.5	14.4	5.67
58	8.9	8.4	17.3	6.81	6.9	7.7	14.6	5.75
60	9.0	8.6	17.6	6.93	6.9	7.6	14.5	5.71
66	10.2	9.8	20.0	7.88	7.7	7.0	14.7	5.79
99	13.1	12.4	25.5	10.03	7.6	8.2	15.8	6.22
132	15.0	14.6	29.6	11.64	7.5	8.5	16.0	6.30

Run 1-01

1 and 2 July 1952

SCOTT AIR PAK
inspiration breathing resistance at surface
for different stroke volumes and rates

VOLUME cc per stroke	RATE strokes per minute	FLOW liters per minute	INSPIRATION High cm.H20	INSPIRATION Low cm H20	INSPIRATION Total cm H20
3620	29	105.0	18.0	18.5	36.5
3620	26	94.1	14.2	14.6	28.8
3620	22	79.6	7.2	7.0	14.2
3620	18	65.2	5.2	4.9	10.1
3620	16	57.9	5.0	4.6	9.6
2600	30	78.0	10.3	10.2	20.5
2600	26	67.6	8.3	8.3	16.6
2600	23	59.8	6.1	5.8	11.9
2600	20	52.0	4.6	4.3	8.9
2600	17	44.2	3.6	3.2	6.8
2600	15	39.0	3.3	2.9	6.2
1976	31	61.3	7.6	7.3	14.9
1976	26	51.4	6.4	6.0	12.4
1976	24	47.4	4.9	4.5	9.4
1976	22	43.5	4.2	3.8	8.0
1976	18	35.6	3.0	2.7	5.7
1976	15	29.6	2.9	2.5	5.4

Run 1-02

RUN REGULATOR	2-01 55	2-15 55	2-05 65	2-13 65	2-07 75	2-11 75	2-08 85	2-09 85	
DEPTH									
0	5.6	6.7	6.1	-	7.0	7.2	7.6	6.7	7.1
130	23.5	24.4	20.1	21.3	17.9	18.5	18.5	17.3	18.0
120	- -	23.1	19.0	20.2	16.5	18.0	17.6	15.9	17.0
110	- -	21.2	18.4	18.8	15.3	16.8	16.4	14.6	15.8
100	18.4	19.9	16.5	17.4	14.5	15.4	15.1	13.5	14.6
95	- -	19.2	16.3	16.7	13.1	15.0	14.4	12.9	13.8
90	16.9	18.5	14.0	16.0	13.1	14.1	13.6	12.5	13.3
85	- -	18.0	13.3	15.1	12.4	13.4	13.2	12.1	12.8
80	15.2	16.9	12.1	13.9	11.6	12.6	12.6	11.9	12.2
75	- -	15.9	11.6	13.1	11.2	12.2	12.4	11.6	11.8
70	12.5	15.0	11.1	12.3	10.9	11.8	12.2	11.4	11.6
65	11.6	13.8	10.6	11.5	10.8	11.5	12.0	11.1	11.3
60	10.4	12.3	10.4	10.7	10.6'	11.3	11.6	10.8	11.1
55	9.4	10.8	10.0	10.4	10.1'	11.0	11.2	10.4	10.7
50	9.0	10.0	9.8	9.9	10.0	10.8	11.0	10.3	10.5
45	8.9	9.4	9.7	9.6	9.9	10.6	10.7	10.1	10.3
40	8.5	8.9	9.4	9.5	9.4	10.3	10.6	10.0	10.1
35	8.4	8.7	9.2	9.2	9.3	10.1	10.6	9.8	10.0
30	8.4	8.6	8.9	8.8	9.1	9.8	10.5	9.4	9.7
25	8.0	8.3	8.7	8.6	8.8	9.4	10.2	9.0	9.3
20	7.8	8.2	8.6	8.3	8.5	9.2	9.8	8.4	9.0
15	7.4	7.9	8.1	8.1	8.1	8.7	9.1	8.0	8.5
10	7.3	7.6	7.9	7.7	7.9	8.5	8.7	7.7	8.2
0	6.0	7.1	7.1	7.0	7.3	7.5	7.8	7.1	7.4

INSPIRATORY PRESSURES - centimeters of water

DATA SHEET 5

RUN	2-01	2-15	2-05	2-31	2-07	2-11	2-08	2-09
REGULATOR	55	55	65	65	75	75	85	85
DEPTH								
0	5.1	6.0	4.9	--	5.5	6.0	5.1	2.9
130	13.5	14.8	14.3	15.2	16.0	16.5	18.0	9.0
120	--	14.5	14.6	15.3	15.5	16.1	17.6	8.7
110	--	14.8	14.0	15.3	15.1	15.6	17.2	8.2
100	13.0	14.8	13.5	15.1	14.9	15.0	16.3	7.4
95	--	14.7	13.0	14.6	13.9	14.8	15.6	7.1
90	13.0	14.5	12.7	14.2	13.4	14.2	15.4	6.9
85	--	14.3	12.4	14.1	13.3	13.9	15.1	6.7
80	12.4	14.2	12.2	13.5	12.9	13.6	14.8	6.6
75	--	13.7	12.1	13.5	12.8	13.5	14.4	6.5
70	11.8	13.4	11.9	13.3	12.7	13.3	13.8	6.5
65	11.5	12.6	11.7	13.0	12.1	12.8	13.5	6.3
60	11.0	12.3	11.3	12.7	11.8	12.4	13.3	6.1
55	--	12.5	11.1	12.4	11.2	12.2	12.6	5.8
50	9.7	12.2	10.9	11.9	11.0	12.0	12.3	5.8
45	9.6	11.9	10.1	11.8	10.9	11.3	11.9	5.4
40	9.2	11.4	9.7	11.1	10.0	10.8	11.2	5.0
35	8.7	10.9	9.0	10.7	9.4	10.7	10.8	5.0
30	8.3	10.4	8.5	9.8	9.1	10.0	10.0	4.7
25	7.7	9.7	7.7	9.3	8.4	9.2	9.3	4.5
20	7.1	9.3	7.2	8.9	7.9	9.0	8.9	4.1
15	6.5	8.7	6.7	8.1	7.1	8.2	8.2	3.9
10	6.0	7.8	6.3	7.7	6.4	7.9	7.5	3.7
00	5.1	6.6	5.4	6.9	5.7	6.4	6.1	3.3

EXPIRATORY PRESSURES - centimeters of water

DATA SHEET 6

Bottle pressure (psig) giving an inspiratory pressure of 20 centimeters of water at various depths for different regulator pressures (psi)

RUN	REGULATOR	130	100	65	35	30	25	20	15	10
2-10	85	1110	980	780	590	590	560	550	500	490
2-12	75	1200	990	810	610	--	- -	550	- -	470
2-14	65	----	1050	800	640	600	560	550	500	480
2-16	55	----	1060	790	620	600	580	540	510	480

Inspiratory pressure (centimeters of water) at various depths when bypass has been opened after inspiratory pressure has reached 20 centimeters of water

RUN	REGULATOR	130	100	65	35	30	25	20	15	10
2-10	85	16.8	16.1	1.17	9.1	9.2	8.9	8.7	7.8	8.2
2-12	75	18.4	15.2	12.4	10.5	- -	- -	9.6	8.8	- -
2-14	65	(28.8)	16.6	10.8	10.2	10.2	9.2	9.2	8.3	8.7
2-16	55	(35.8)	17.9	12.0	9.2	9.2	9.0	8.7	7.8	8.2

DATA SHEET 7

IX. FIGURE

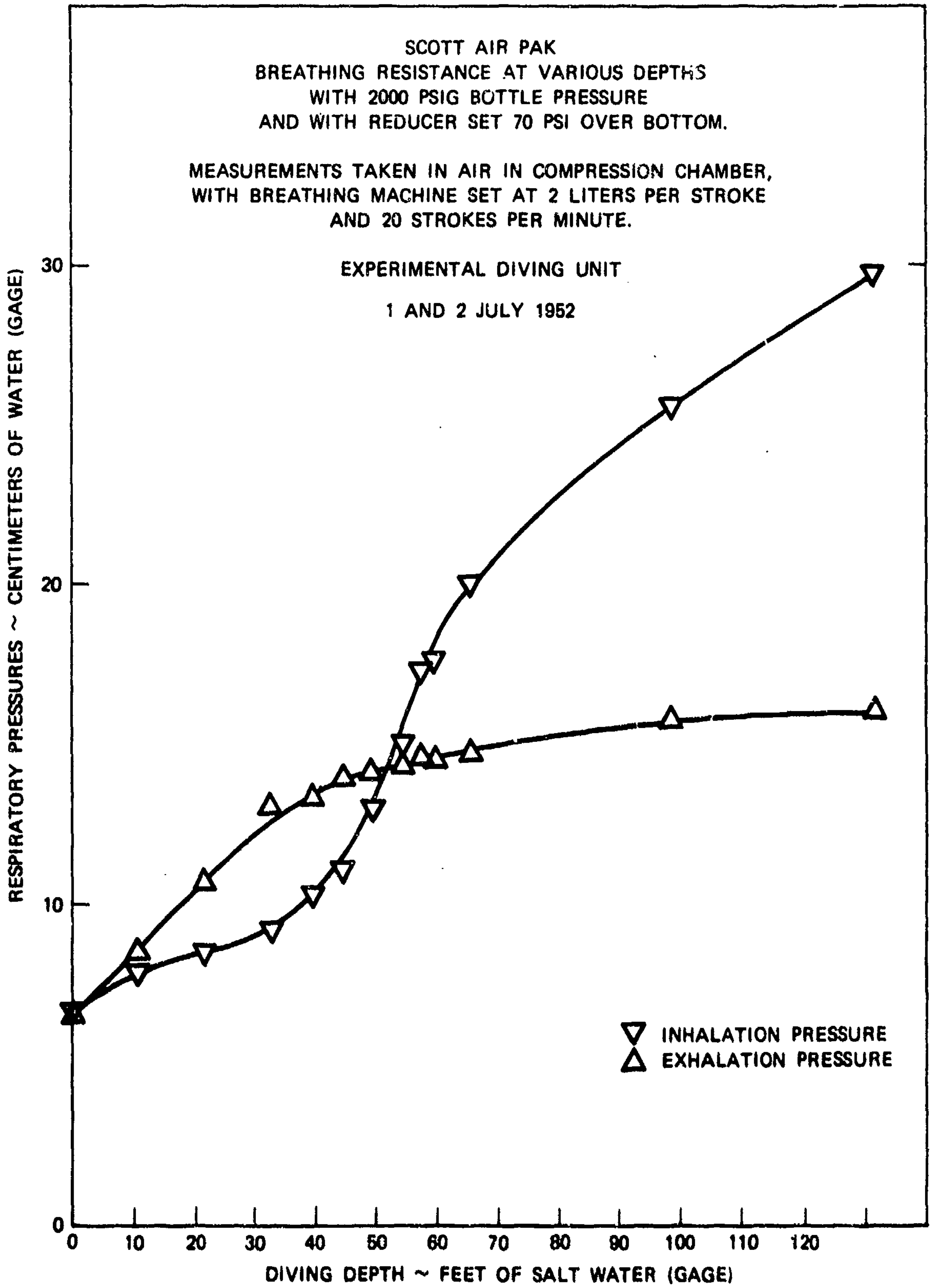

SCOTT AIR PAK
BREATHING RESISTANCE AT VARIOUS DEPTHS
WITH 2000 PSIG BOTTLE PRESSURE
AND WITH REDUCER SET 70 PSI OVER BOTTOM.
MEASUREMENTS TAKEN IN AIR IN COMPRESSION CHAMBER,
WITH BREATHING MACHINE SET AT 2 LITERS PER STROKE
AND 20 STROKES PER MINUTE.
EXPERIMENTAL DIVING UNIT
1 AND 2 JULY 1952
RESPIRATORY PRESSURES ~ CENTIMETERS OF WATER (GAGE)
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
INHALATION PRESSURE
EXHALATION PRESSURE
DIVING DEPTH ~ FEET OF SALT WATER (GAGE)

FIGURE 1

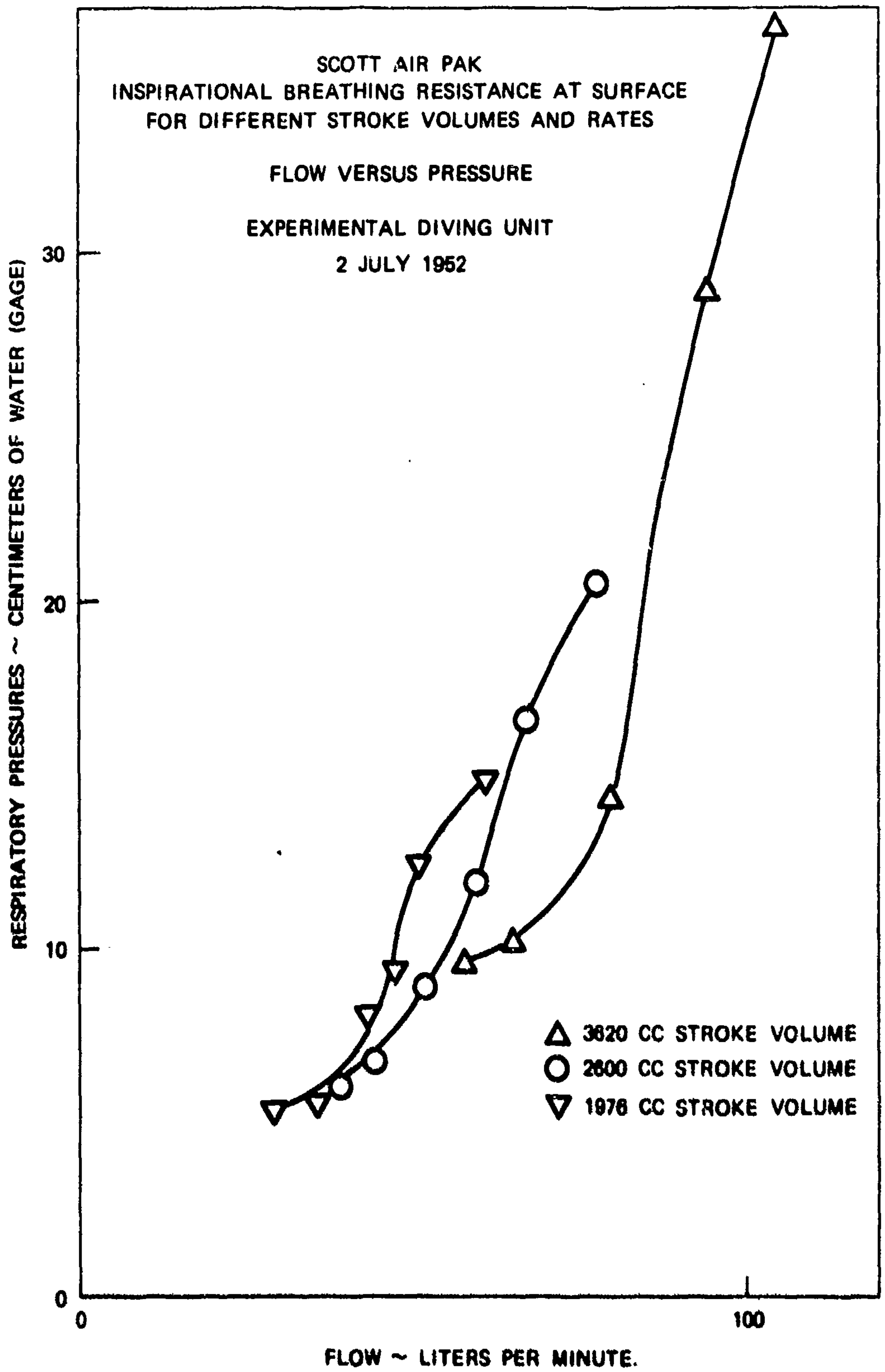

SCOTT AIR PAK
INSPIRATIONAL BREATHING RESISTANCE AT SURFACE
FOR DIFFERENT STROKE VOLUMES AND RATES
FLOW VERSUS PRESSURE
EXPERIMENTAL DIVING UNIT
2 JULY 1952
RESPIRATORY PRESSURES ~ CENTIMETERS OF WATER (GAGE)
0
10
20
30
0
100
FLOW ~ LITERS PER MINUTE.
3620 CC STROKE VOLUME
2600 CC STROKE VOLUME
1976 CC STROKE VOLUME

FIGURE 2

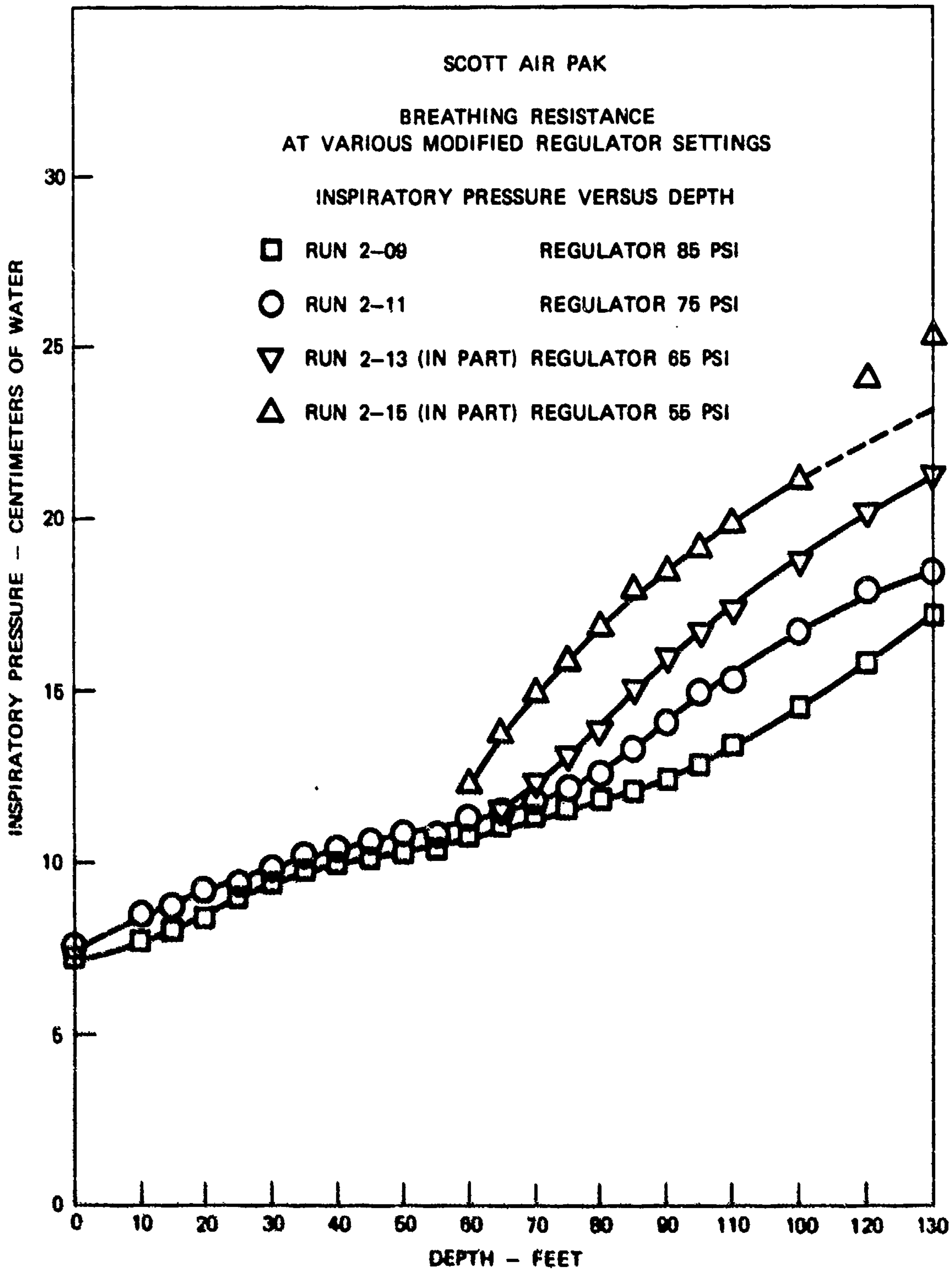
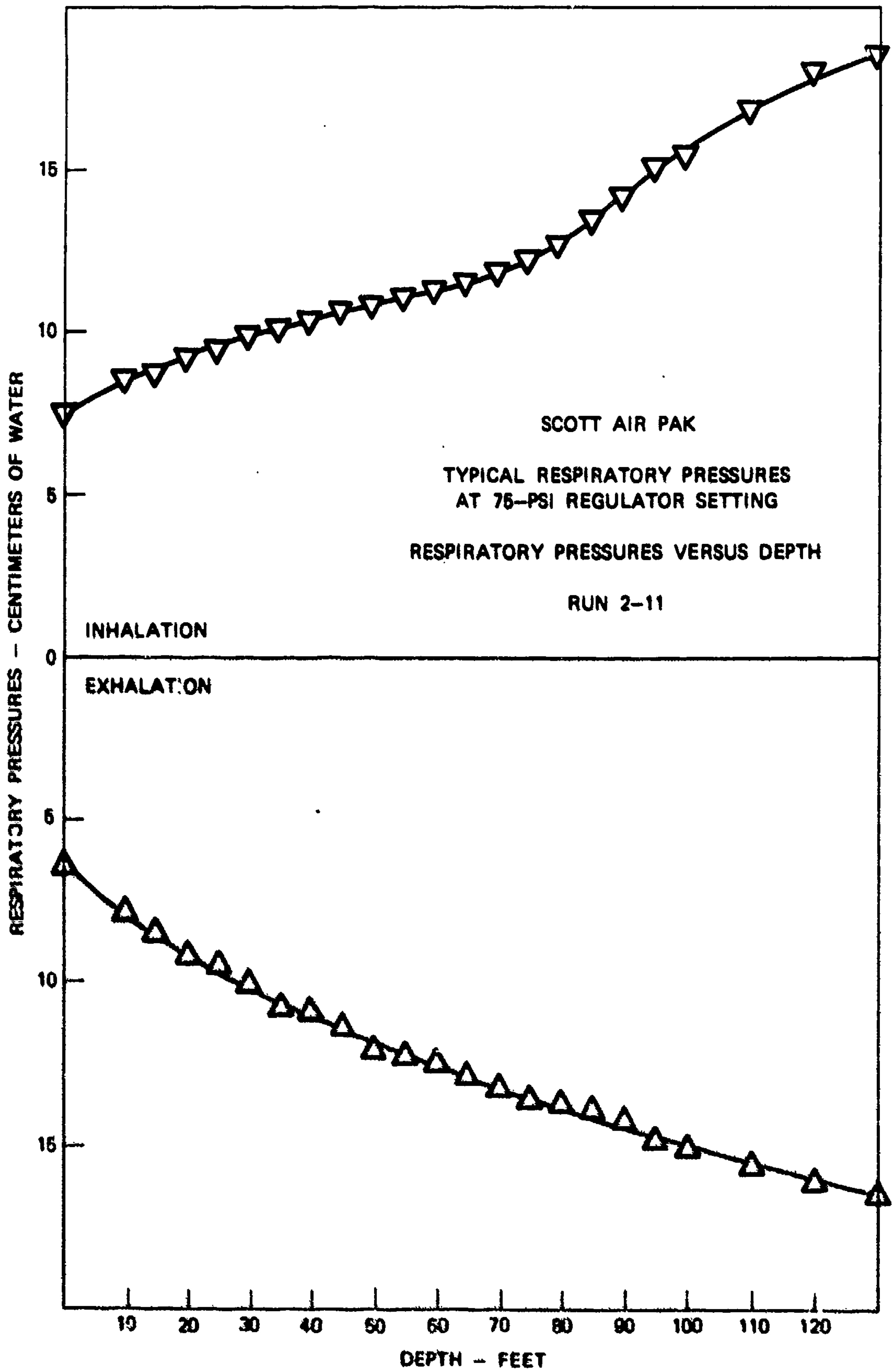
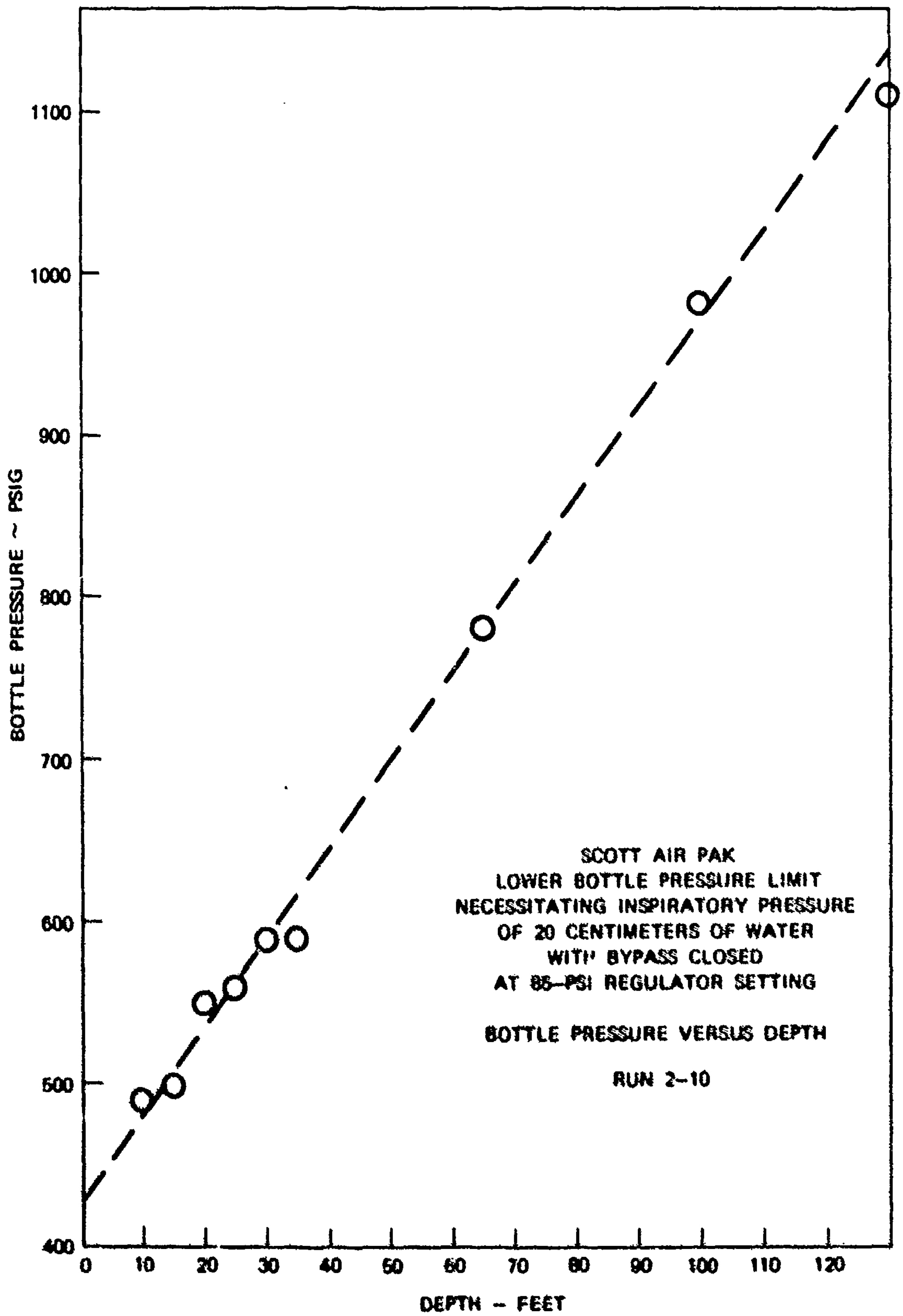

SCOTT AIR PAK
BREATHING RESISTANCE
AT VARIOUS MODIFIED REGULATOR SETTINGS
INSPIRATORY PRESSURE VERSUS DEPTH
RUN 2-09 REGULATOR 85 PSI
RUN 2-11 REGULATOR 75 PSI
RUN 2-13 (IN PART) REGULATOR 65 PSI
RUN 2-15 (IN PART) REGULATOR 55 PSI
INSPIRATORY PRESSURE – CENTIMETERS OF WATER
0
5
10
15
20
25
30
0 10 20 30 40 50 60 70 80 90 110 100 120 130
DEPTH – FEET

FIGURE 3



SCOTT AIR PAK
TYPICAL RESPIRATORY PRESSURES
AT 75-PSI REGULATOR SETTING
RESPIRATORY PRESSURES VERSUS DEPTH
RUN 2-11
INHALATION
EXHALATION
RESPIRATORY PRESSURES - CENTIMETERS OF WATER
15
10
5
0
5
10
15
10
20
30
40
50
60
70
80
90
100
110
120
DEPTH - FEET

FIGURE 4



SCOTT AIR PAK
LOWER BOTTLE PRESSURE LIMIT
NECESSITATING INSPIRATORY PRESSURE
OF 20 CENTIMETERS OF WATER
WITH BYPASS CLOSED
AT 85-PSI REGULATOR SETTING
BOTTLE PRESSURE VERSUS DEPTH
RUN 2-10
BOTTLE PRESSURE ~ PSIG
DEPTH — FEET
400
500
600
700
800
900
1000
1100
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 5

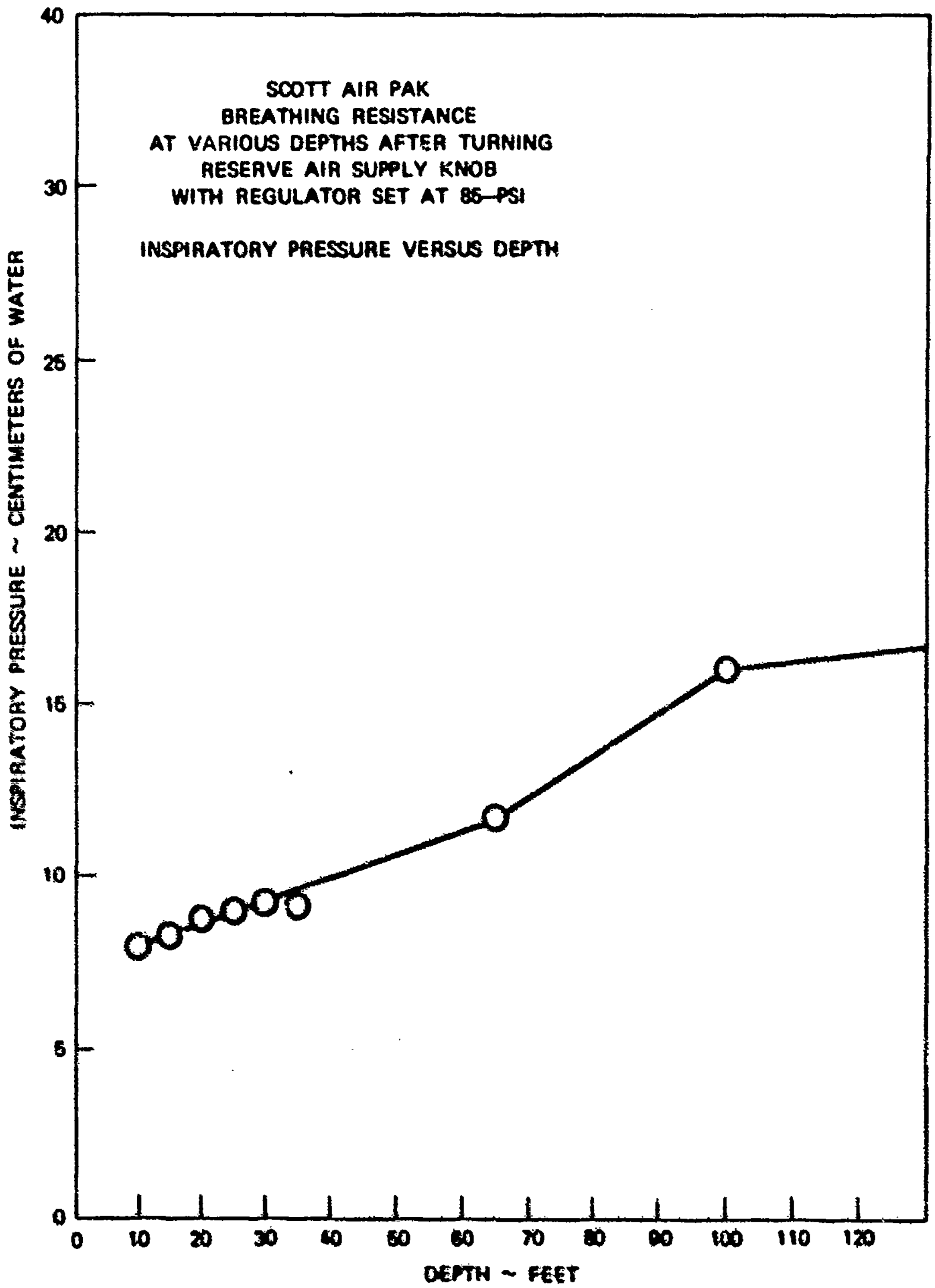

SCOTT AIR PAK
BREATHING RESISTANCE
AT VARIOUS DEPTHS AFTER TURNING
RESERVE AIR SUPPLY KNOB
WITH REGULATOR SET AT 85—PSI
INSPIRATORY PRESSURE VERSUS DEPTH
INSPIRATORY PRESSURE ~ CENTIMETERS OF WATER
DEPTH ~ FEET
0
5
10
15
20
25
30
40
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 6